INDOOR AIR QUALITY ASSESSMENT

North Attleborough Middle School
564 Landry Avenue
North Attleborough, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Richard Smith, District Superintendent of North Attleborough Public Schools, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at North Attleborough Middle School (NAMS), 564 Landry Avenue, North, Attleborough, MA. The request was prompted by concerns about mold as a result of excessively humid weather during the first three weeks of August 2003.

On October 23, 2003, a visit to conduct an indoor air quality assessment was made to this school by Cory Holmes, Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. The assessment was primarily focused on mold. Mr. Holmes was accompanied by Roland Deneault, Facilities Director, North Attleborough School Department (NASD) and William Wing, Senior Custodian.

The NAMS is a three-story, red brick on slab building constructed in 1998. The school contains general classrooms, science classrooms, several music rooms, media center, gymnasium and locker rooms, cafeteria, art rooms and office space.

The NASD staff provided BEHA staff with copies of reports, letters and memorandum related to the IAQ/mold concerns at the NAMS. School officials have reportedly made attempts to address concerns. An indoor air quality study was conducted at the NAMS by a consultant, Diversified Environmental Corporation (DEC), in September of 2003. This consultant recommended the following remedial actions:

- Clean flat surfaces and carpets in all areas that experienced high humidity or have a potential for mold growth;
- Replace water damaged/mold-colonized building materials;

- Contact an engineering firm to examine and repair all exterior water infiltration areas so as to prevent further water penetration;
- Install de-humidifiers in areas with elevated relative humidity;
- Clean non-porous surfaces/materials using damp cleaning methods and high efficiency particulate air (HEPA) vacuuming to reduce dust accumulation in classrooms, including supply and exhaust vents;
- Review policies for opening of ground floor windows to reduce dust infiltration; and
- Institute a program for inspecting and cleaning exhaust and supply duct systems (DEC, 2003).

The NASD hired LVI Environmental Services, Inc. (LVI), an environmental remediation firm, to perform microbial remediation and cleaning services recommended in the DEC report. In addition, the NASD reported that maintenance staff have improved cleaning practices and increased filter changes for HVAC units.

Methods

BEHA staff performed visual inspection of building materials for water damage and/or microbial growth. Moisture content of carpeting and gypsum wallboard (GW) was measured with a Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe. Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The school houses grades 6-8 with a student population of approximately 1,200 and a staff of approximately 140. The tests were taken during normal operations at the school. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million of air (ppm) in fourteen of twenty-nine areas, indicating inadequate ventilation in some of the areas surveyed. Mechanical ventilation is provided by rooftop air-handling units (AHUs). Fresh air is drawn into outside air intakes and distributed to ceiling or wall-mounted air diffusers via ductwork (Picture 1). Exhaust ventilation is provided by ceiling or wall-mounted exhaust grills that are ducted back to AHUs (Picture 2). It is important to note that two of the rooftop AHUs were reportedly not operating during the assessment due to mechanical difficulties. Therefore fresh outside air was not being mechanically introduced to these areas, which can contribute to increased carbon dioxide levels. Mr. Deneault reported that the school department's HVAC engineering firm was contacted to repair the system.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical ventilation system, the systems must be balanced subsequent to installation to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems reportedly occurred in

2000. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see Appendix A.

Temperature measurements ranged from 69^{o} F to 74^{o} F, which were very close to the BEHA recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Building occupants expressed a variety of temperature control/comfort complaints. Complaints included excess heat in the media center and locker room offices, as well as cold temperatures in classroom 300. An occupant's desk in classroom 300 was located in front of a window-mounted air conditioner (AC) (Picture 3). The assessment occurred on a cold, windy day. BEHA staff detected drafts around the AC unit, indicating pathways for cold air to enter the classroom from outside.

The relative humidity measured in the building ranged from 29 to 41 percent, which was below the BEHA recommended comfort range in most areas. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

In the experience of BEHA staff, excessively humid weather can provide enough airborne water vapor to create adequate conditions for mold growth in buildings. Relative humidity in excess of 70 percent can provide an environment for mold and fungal growth (ASHRAE, 1989). In general, materials that are prone to mold growth can become colonized when moistened for more than 24-48 hours. Since hot, humid weather persisted in Massachusetts for more than 14 days during the month of August (The Weather Underground, 2003), materials in a many schools and buildings were moistened for an extended period of time.

For example, at the NAMS, carpeting in the lower levels became moistened. The carpeting was not dried with mechanical aids (e.g., fans, dehumidifiers); as a result, mold growth occurred on the surface of carpeting.

As discussed, the NASD hired LVI, an environmental remediation firm to perform mold remediation. According to LVI, cleaning included disposal of all mold colonized items, cleaning of non-porous surfaces using HEPA filtered vacuum cleaners and wet wiping methods, HEPA vacuuming of all carpets followed by steam extraction using high heat and drying of carpeting using floor blowers and dehumidifiers (LVI, 2003). No evidence of active mold growth, or elevated moisture content was detected in carpeting at the time of the BEHA assessment.

Missing/damaged ceiling tiles were observed in classroom 122. BEHA staff examined conditions above the ceiling plenum and found no visible water damage, mold growth or associated odors. GW above the ceiling tile system was determined to have low moisture content. Stained GW was seen in art room 102. The water damage appeared to be a result of condensation forming on uninsulated pipes used for cooling conditioned air. Moisture measurements of GW were determined to have low moisture content in this area.

BEHA staff did observe active mold growth on GW in a storage closet in room 301 as a result of a leak in the HVAC system (Picture 4). At the time of the assessment, BEHA staff recommended that the water damaged GW be removed and replaced. [Note: In a subsequent conversation with Mr. Wing, he reported that all water damaged building materials in the storage room were removed and replaced].

The US Environmental Protection Agency and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24-48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

School officials reported that the building has problems with water pooling on the ground outside of classrooms 120-122 during heavy rains (Picture 5). Town and school officials are reportedly investigating plans to improve drainage in the area. In addition, shrubbery and other plants were growing in close proximity to foundation walls (Picture 6). The combination of the downgradient position of the building and the growth of roots against the exterior walls can bring moisture in contact with wall brick. Plant roots can eventually penetrate the brick, leading to cracks and/or fissures in the below ground level foundation. Over time, this process can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001).

Other Concerns

Several other conditions that can affect indoor air quality were noted during the assessment. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat. Accumulated dry erase particles was noted in some classrooms, which can also serve as a source of airborne particulates.

A number of exhaust/return vents were noted with accumulated dust (Picture 7). If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize accumulated dust particles. Classroom 328 contained a clothes dryer. BEHA staff inspected the dryer for proper ventilation and found the flexible exhaust duct was kinked, preventing proper airflow (Picture 8). Dryers must be properly vented to remove excess heat, moisture and particulates.

Also of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provide a source for dusts to accumulate. These items, (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

Finally, a strong chemical odor was detected in classroom 123. The source of this odor appeared to be a plug-in type air freshener. The ventilation system was not operating in this area during the assessment, therefore there was no mechanical dilution or removal of this odor. Lack of dilution/removal results in the accumulation of the fragrance. Air fresheners contain chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. Furthermore, air fresheners do not remove materials causing odors, but rather mask odors that may be present in the area.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Continue to work with an HVAC engineer to repair the ventilation system. Have the engineer survey classrooms to ascertain if an adequate air supply exists for each room.

2. Operate both supply and exhaust ventilation continuously, independent of classroom thermostat control, during periods of school occupancy to maximize air exchange.
3. Adopt scrupulous cleaning practices. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (e.g., throat and sinus irritations).
4. Continue working with town officials to improve drainage and prevent water pooling on grounds outside of classrooms 120-122. Consider building up landscape against the building to create a berm.
5. Remove plant growths against the exterior wall/foundation of the building to prevent water accumulation.
6. Clean chalkboards and dry erase board trays regularly to avoid the build-up of particulates.
7. Clean exhaust/return vents periodically to prevent excessive dust build-up.
8. Replace missing/dislodged ceiling tiles.
9. Reduce the length of the flexible dryer exhaust pipe to facilitate airflow.
10. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
11. For further information on mold, consult “Mold Remediation in Schools and Commercial Buildings” published by the US Environmental Protection Agency (US EPA, 2001). Copies of

this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html.

12. Refrain from using strongly scented materials (e.g., air fresheners) in classrooms.
13. Consider adopting the US EPA document, "Tools for Schools" in order to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.
14. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

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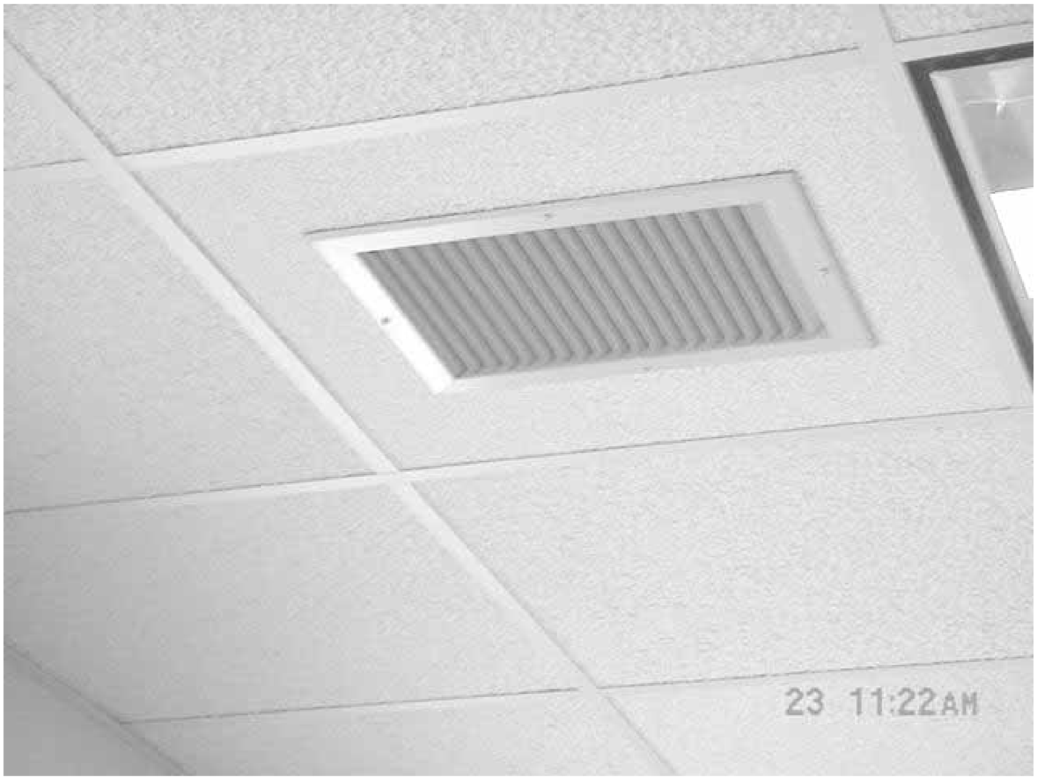
Picture 1

Fresh Air Diffuser for HVAC System

Picture 2

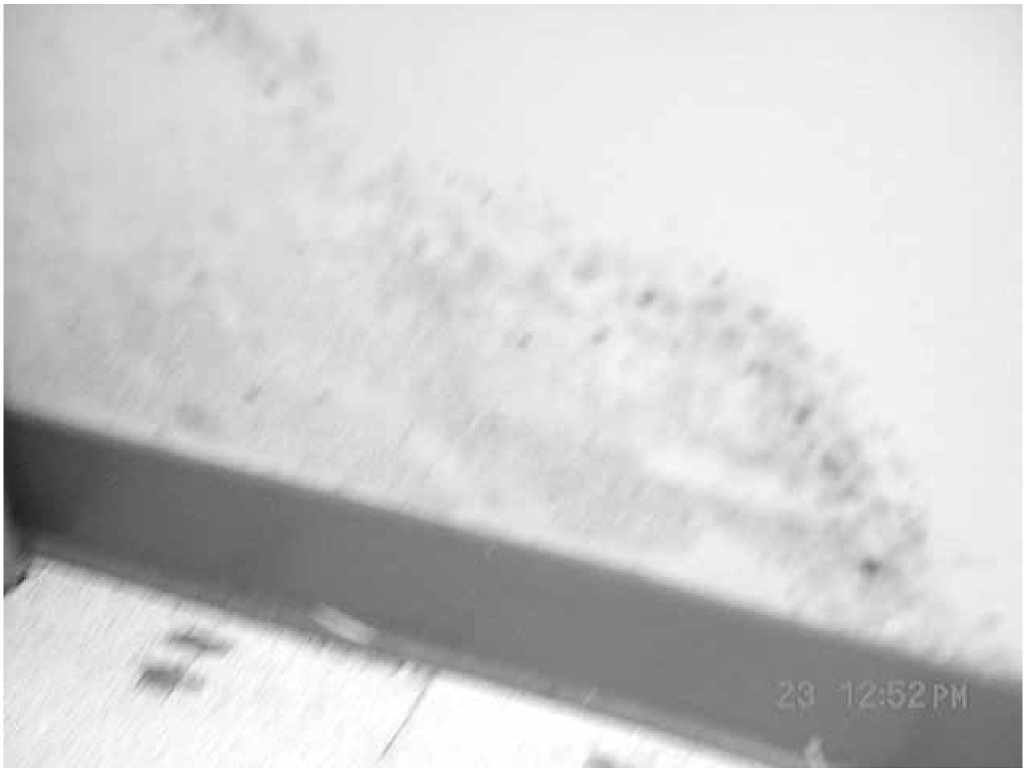


Return Vent for HVAC System

Picture 3

Proximity of Occupants Desk to "Drafty" Window Mounted AC

Picture 4



Mold Growth (as Indicated by Dark Stains) on GW in Classroom 301 Storeroom

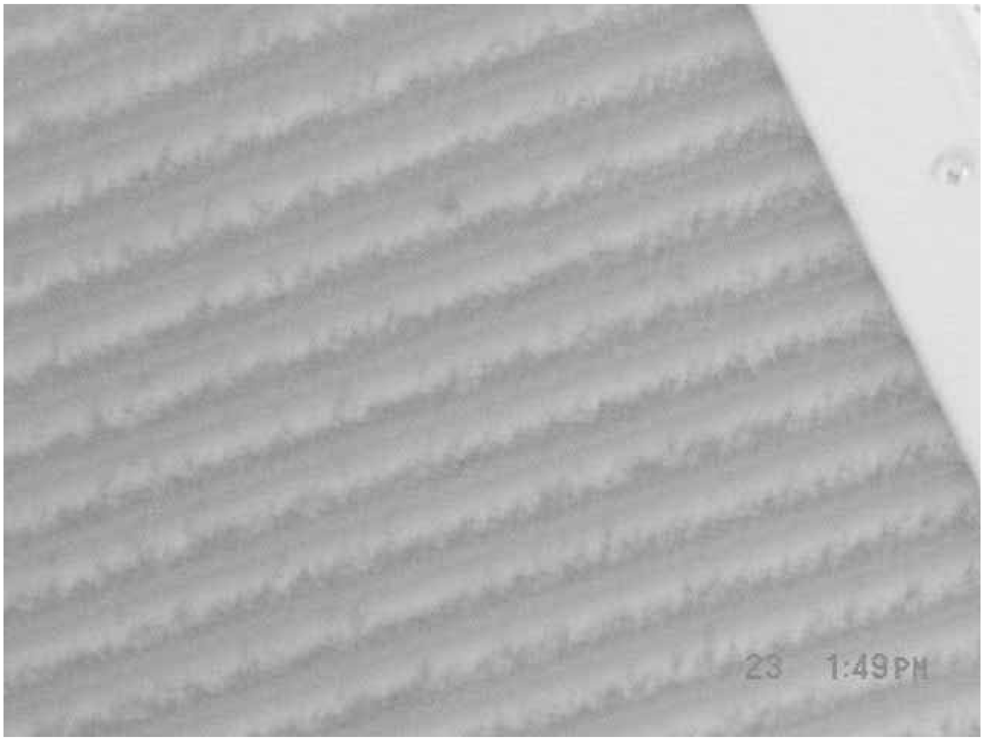
Picture 5

Sloped Area Outside Classrooms 120-122, Note Shrubbery in Close Proximity to the Exterior Brick Bag Placed to Indicate Position of Drain

Picture 6

Shrubbery Near Exterior Brick Outside Classrooms 120-122

Picture 7



Return Vent With Accumulated Dust

Picture 8

“Pinched” Clothes Dryer Vent in Classroom 328

Building: North Attleborough Middle School | **Indoor Air Test Results**
Address: North Attleborough, MA | **Date: 10/23/03**

TABLE 1

Location/Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Background	48	40	360					Light flurrys, cold, overcast, winds 10-15 MPH
Room 120	71	41	1065	29	Y	N	Y	Occupant reported lingering odors, carpeted, GW/cinderblock, Rubber coving, Moisture carpet low 0-0.1, DH, DEM
Girl's Locker Rm	72	38	654	0	N	Y	Y	
Room 328	69	38	721	13	Y	Y	Y	Clothes dryer, Flex duct "pinched"
Room 329	70	36	818	18	Y	Y	Y	Little airflow, DEM, WD-CT
Room 303	71	38	916	14	Y	Y	Y	Little airflow, DEM
Room 209	71	34	1042	22	Y	N	Y	DEM
Nurse's Office	73	31	488	6	Y	N	Y	
Room 104	70	30	708	23	Y	N	Y	DEM
Room 101	71	30	573	15	Y	Y	Y	DEM, DH

ppm = parts per million parts of air

AD = air deodorizer
AHU = air-handling unit
AP = air purifier
AC = air conditioning
CD = chalk dust

CT= ceiling tile
DEM = dry erase marker
DO = door open
MT= missing ceiling tile
PC = photocopier

PF = personal fan
TB = tennis balls
UF = upholstered furniture
WD = water damage

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Building: North Attleborough Middle School **Indoor Air Test Results**
Address: North Attleborough, MA **Date: 10/23/03**

TABLE 1

Location/Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Room 300	69	33	640	1	N	Y	Y	Cold complaints, Window AC (drafts), Desk in front of AC
Music Room	71	33	640	17	N	Y	Y	
Boy's Locker Rm	69	38	754	0	N	Y	Y	Bubbler on carpet, Dust, Temp issues in office (heat), Poor air flow
Gym	69	40	939	140	N	Y	Y	
Room 118	71	34	1113	27	Y	Y	Y	DEM
Room 112A	70	29	487	1	Y	N	Y	8 occupants gone 25 minutes, DEM
Room 122	72	35	744	26	Y	Y	Y	Plants in standing water, DEM, Aquarium (standing water), MT - water leak believed to be from washing upstairs floor no WD or visible mold growth, Int wall moist 0.3, Moist low 0.2-0.3
Room 121	71	37	1034	19	Y	Y	Y	DEM, Aquarium

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						Supply	Exhaust	
Room 123	73	36	980	9	Y	N	Y	DEM, Plug-in air fresheners (2), Strong chemical odor, Supply off, AHU being worked on
Room 124	72	35	867	1	N	N	Y	Supply not open in this wing, bubbler on carpet
Media Center	71	32	484	4	Y	Y	Y	Temp cont issues, No exhaust vent in main frame room - media director's office
Room 125	71	34	842	8	Y	N	Y	
Room 123	74	37	1246	0	Y	N	Y	WD carpet, 23 occupants 2 minutes ago, removed coving - no mold growth on wall base
Art 128	73	33	775	7	Y	N	Y	
Art 102	73	34	903		Y	N	Y	DEM, WD GW (from potential condensation leak), Low Moisture - 0.1-0.3, INT wall 0.2
Room 301	71	33	510	13	N	Y	Y	Mold growth GW, visible old, WD CT, WD GW
Room 108	71	33	1039	21	Y	N	Y	DEM

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						Supply	Exhaust	
Room 105 (Comp Room)	78	35	994	26	Y	Y	Y	DEM
Room 305 (Comp Lab)	73	35	684	0	Y	Y	Y	DEM
Room 307	70	30	549	26	N	Y	Y	DEM

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